

Climate and Land Use Change
Earth Resources Observation and Science (EROS) Center

The requirement for high quality data and information for Science

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JACIE Civil Commercial Imagery Evaluation
Workshop, 29 March 2011

Outline

- **USGS Restructure**
- **DOI USGS Remote Sensing**
- **USGS Landsat Status**
- **USGS Operational Mission**
- **New Landsat science data products**
- **Need for accurate data for science**
- **Summary**

USGS Organization

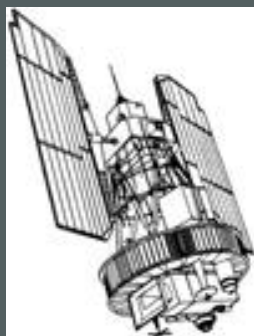
- **USGS was formerly organized by discipline**
 - Geology, Water, Biology, and Geography
 - Land Remote Sensing Program was in Geography
- **USGS is now organized around our Science Strategy**
 - Ecosystems, Climate and Land Use Change, Hazards, Energy/Minerals/ Env Health, Core Science Systems
 - Land Remote Sensing now aligns with *Climate and Land Use Change*
- **Underscores the importance of calibration and validation**

DOI USGS Role in Satellite Remote Sensing

1966 - Initiated Earth Resources Observation Systems Program

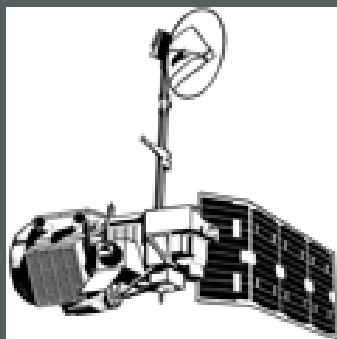
“...the time is now right and urgent to apply space technology towards the solution of many pressing natural resource problems being compounded by population and industrial growth.”

Secretary of the Interior Stewart L. Udall, 1966



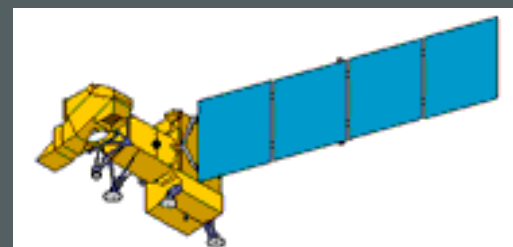
Landsat 1-3

Multi-Spectral Scanner (MSS) 79 meter
Return Beam Vidicon (RBV) 80/40 meter



Landsat 4-5

Multi-Spectral Scanner (MSS) 79 meter
Thematic Mapper (TM) 30 meter



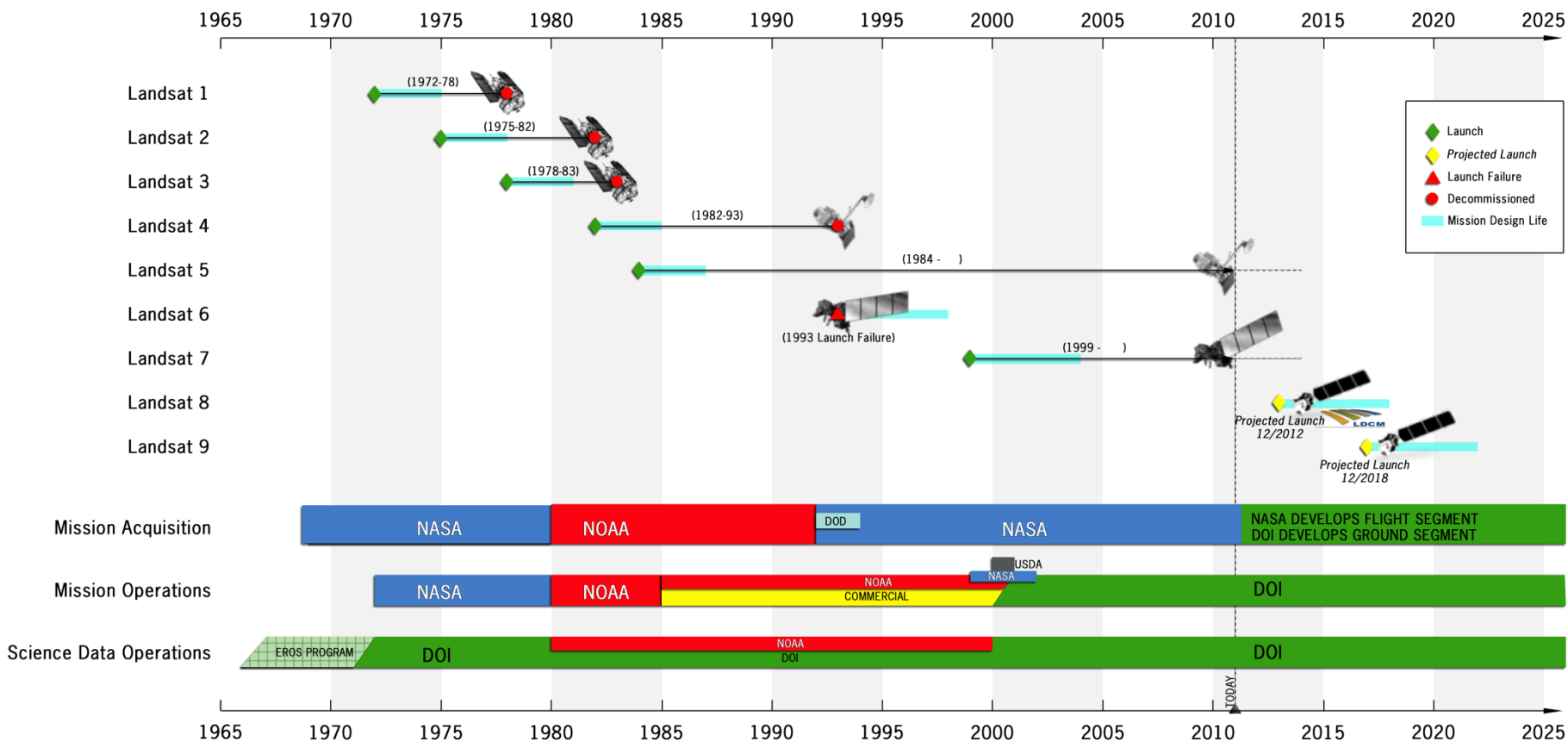
Landsat 7

Enhanced Thematic Mapper Plus (ETM+) 30/15 meter

DOI Owns and Operates Landsat 5 & 7 and Archives Earth Observation Data from Six Operational Landsat Satellites



Landsat History



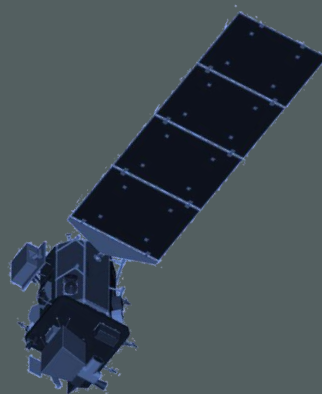
LDCM Characteristics

Mission Characteristics

- Orbit: Polar, 705km circular, sun-synchronous (WRS2), 98.2° inclined, mid-morning, 16-day repeat
- Launch Date: Dec. 2012; Launch Vehicle: Atlas V 401
- Mission Life: 5 Years (with consumables 10 years)
- Mission Project Management: NASA/USGS
- Mission transition to USGS at IOC

Spacecraft (Orbital Sciences)

- 3-axis stabilized
- Observatory Mass of 3085kg
- Maximum power of 2130W
- 3Tb Solid State Recorder
- 384Mbps X-band downlink



Operational Land Imager (OLI)

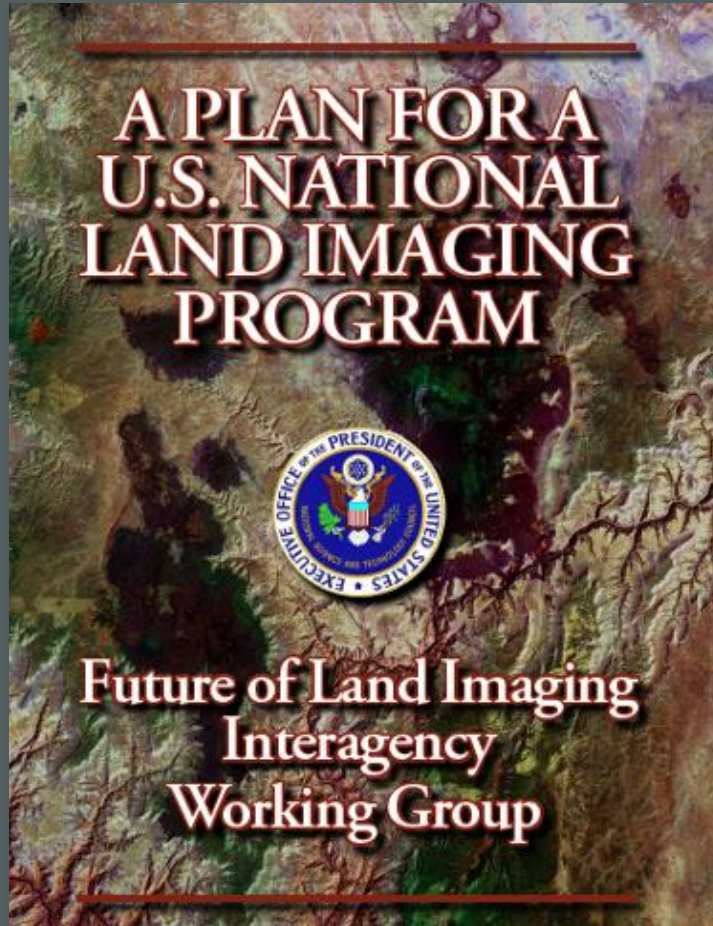
(Ball Aerospace and Technologies Corp.)

- 9 spectral bands (including new deep blue and cirrus bands)
- 30m resolution for VIS/NIR/SWIR, 15m for PAN
- 185km swath width
- Collect 400 WRS-2 scenes/day; 265Mbps

Thermal Infrared Sensor (TIRS)

- TIRS in initial design at NASA; proposed in American Recovery and Investment Act of 2009
- Approximately 100m resolution in 2 bands; 185km swath

OSTP 2007 Call for a DOI/USGS Operational Land Imaging Satellite Program



- The U.S. must commit to continue the collection of moderate-resolution land imagery.
- The U.S. should establish and maintain a core operational capability to collect moderate-resolution land imagery through the procurement and launch of a series of U.S.-owned satellites (Landsat 9 and beyond).
- The U.S. should establish the National Land Imaging Program, hosted and managed by the Department of the Interior, to meet U.S. civil land imaging needs.



DOI USGS Accepted the Challenge

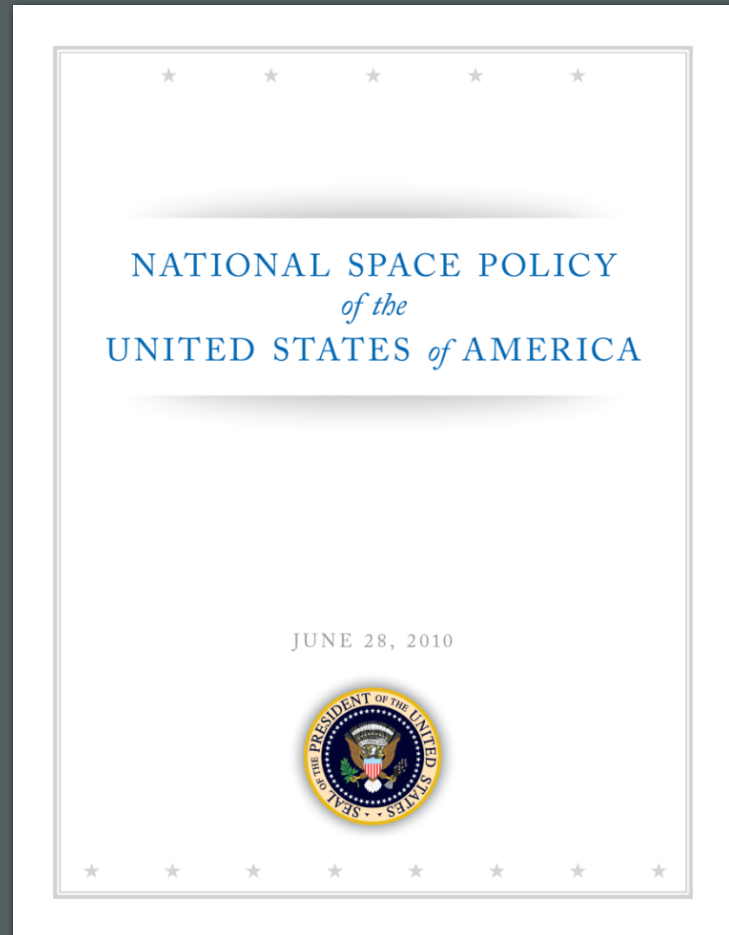
- USGS moved to make the entire 38-year Landsat archive available to anyone, anywhere, at anytime via the Internet at no cost – FREE DATA!
- After implementation of the free Landsat data policy, 3125 scenes delivered per day
- Previously, the best year for Landsat distribution was 2001, with 53 scenes delivered per day

“ The opening of the Landsat archive to free, web-based access, is like giving a library card for the world’s best library of Earth conditions to everyone in the world.”

Adam Gerrand, Food and Agricultural Organization of the United Nations (FAO) – Forest Assessment

2010 National Space Policy

- The President's new National Space Policy endorses DOI/USGS leadership of operational land remote sensing
- Policy implementation calls for clear delineation of roles and responsibilities between DOI/USGS and NASA for a series of U.S. land remote sensing satellites
- President's FY 12 Budget Request provides \$48 M via a separate treasury account for USGS to begin operational program



USGS and NASA are working together to establish an operational land remote sensing program

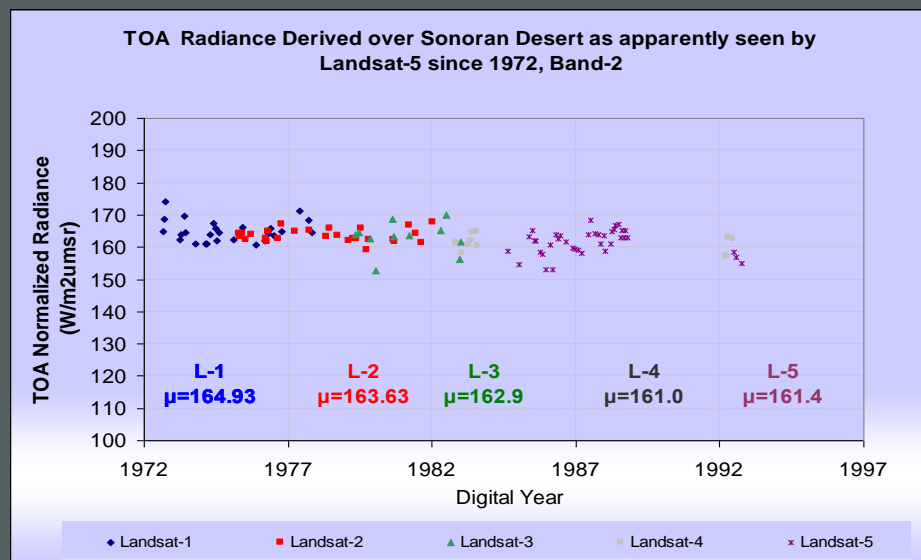
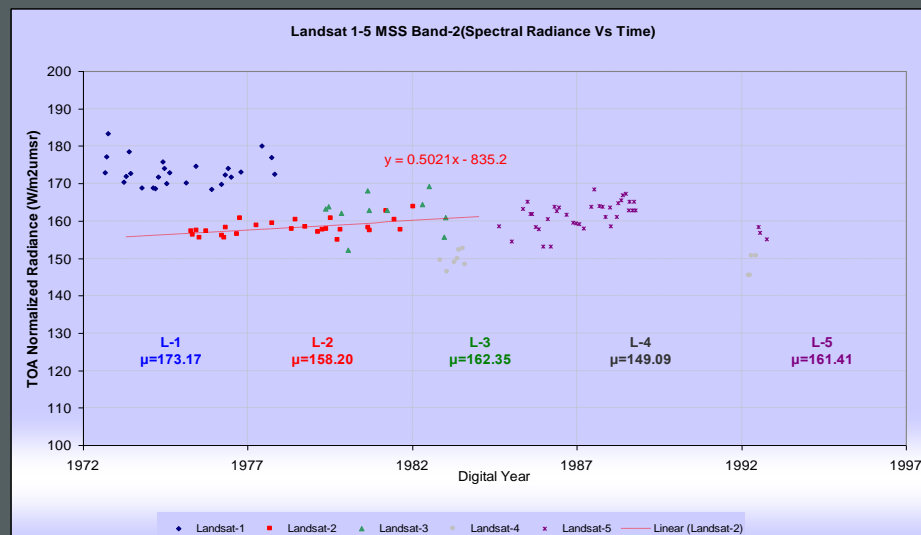


Landsat as an Operational Program

- Landsat will use reliable and proven technologies designed to provide unbroken streams of data over extended periods of time
- New Landsat missions will launch on regular intervals to reduce the likelihood of a Landsat data gap
- Moving from single research missions (**one-offs**) to continuous operational missions (**cycled designs and launches**) will substantially reduce overall cost of design and construction and risk of a data gap

Calibration and Validation are required to develop science products

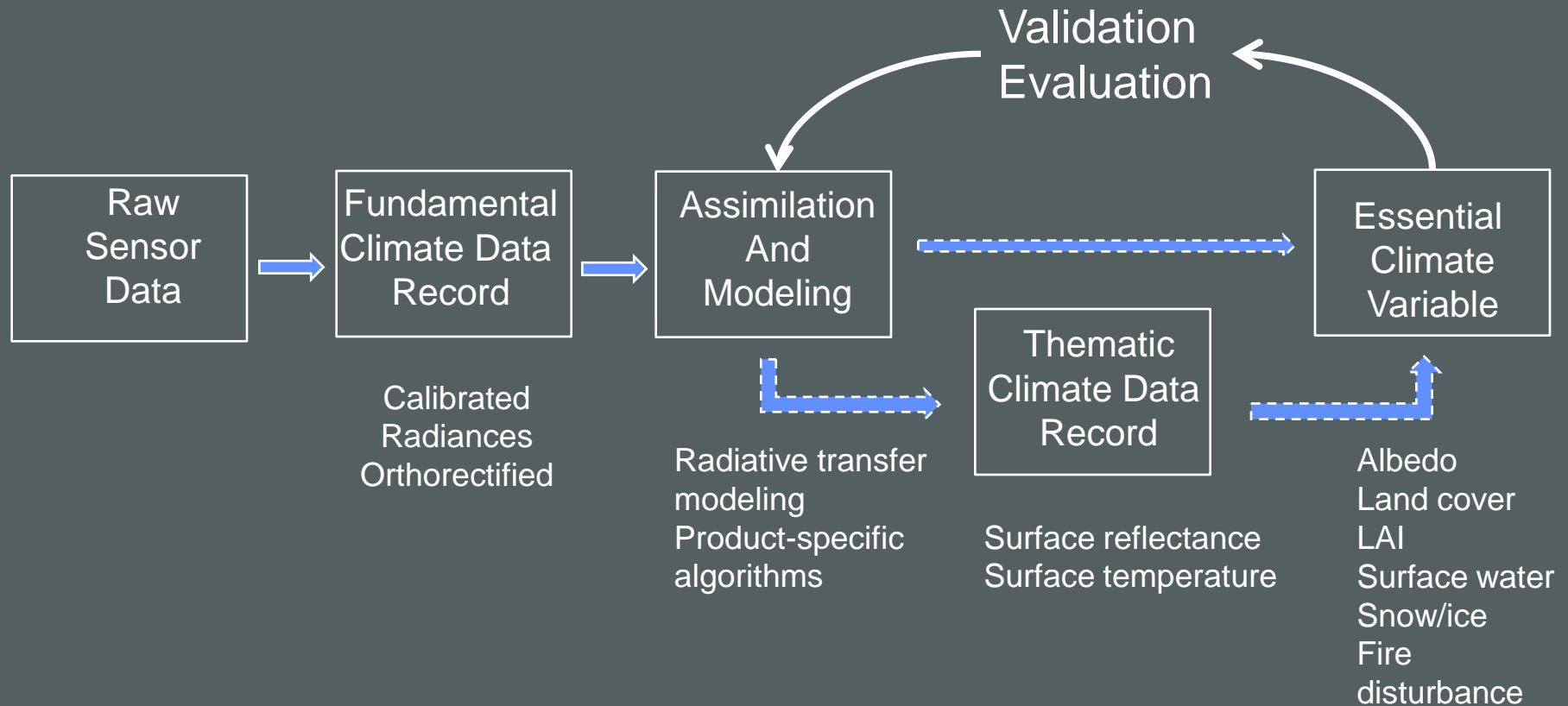
- Calibration is needed
 - To ensure accurate data and science products across instruments and missions (active and archived)
 - All Landsat missions have been calibrated and recently recalibrated w/ L-7
- In situ validation is required



Calibration and Validation are Essential

- **Detection and quantification of environmental trends and anomalies requires homogeneous, long term time-series of observations**
- **Scientific users need to know:**
 - Which part of the EM spectrum they are looking at (**Spectral**)
 - How much energy the instrument is receiving (**Radiometric**)
 - Where the energy is coming from
 - Center of pixel location (**Geometric**)
 - Bounds of the area from which the energy is coming (**Spatial**)
- **Extraneous sources of variation must be eliminated**
- **Calibration and validation are vital pre-requisites**

Operationally Processing Data into Information



Leaf Area Index - California

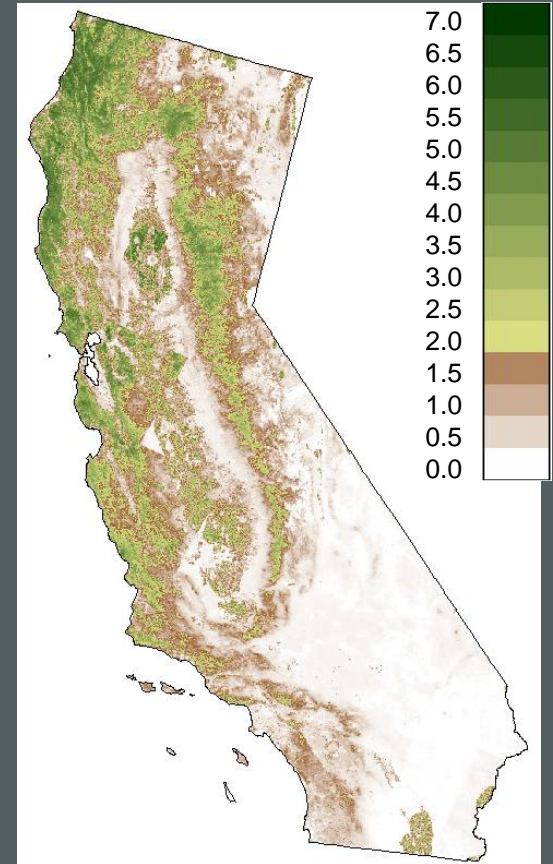
L1T At-sensor Radiance
(FCDR)



Surface Reflectance
(TCDR)

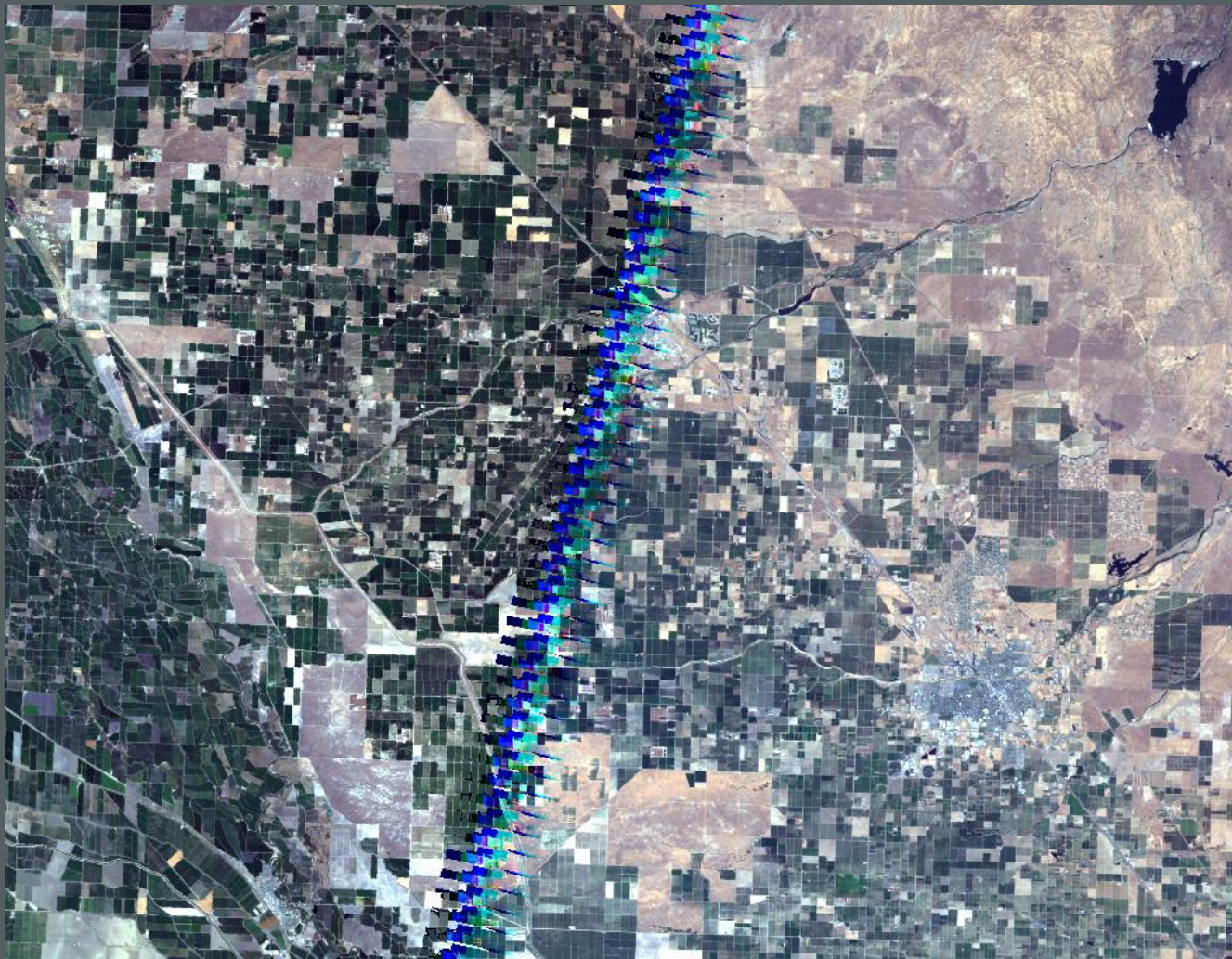


Leaf Area Index
(ECV)



Mosaic of Adjacent Scenes

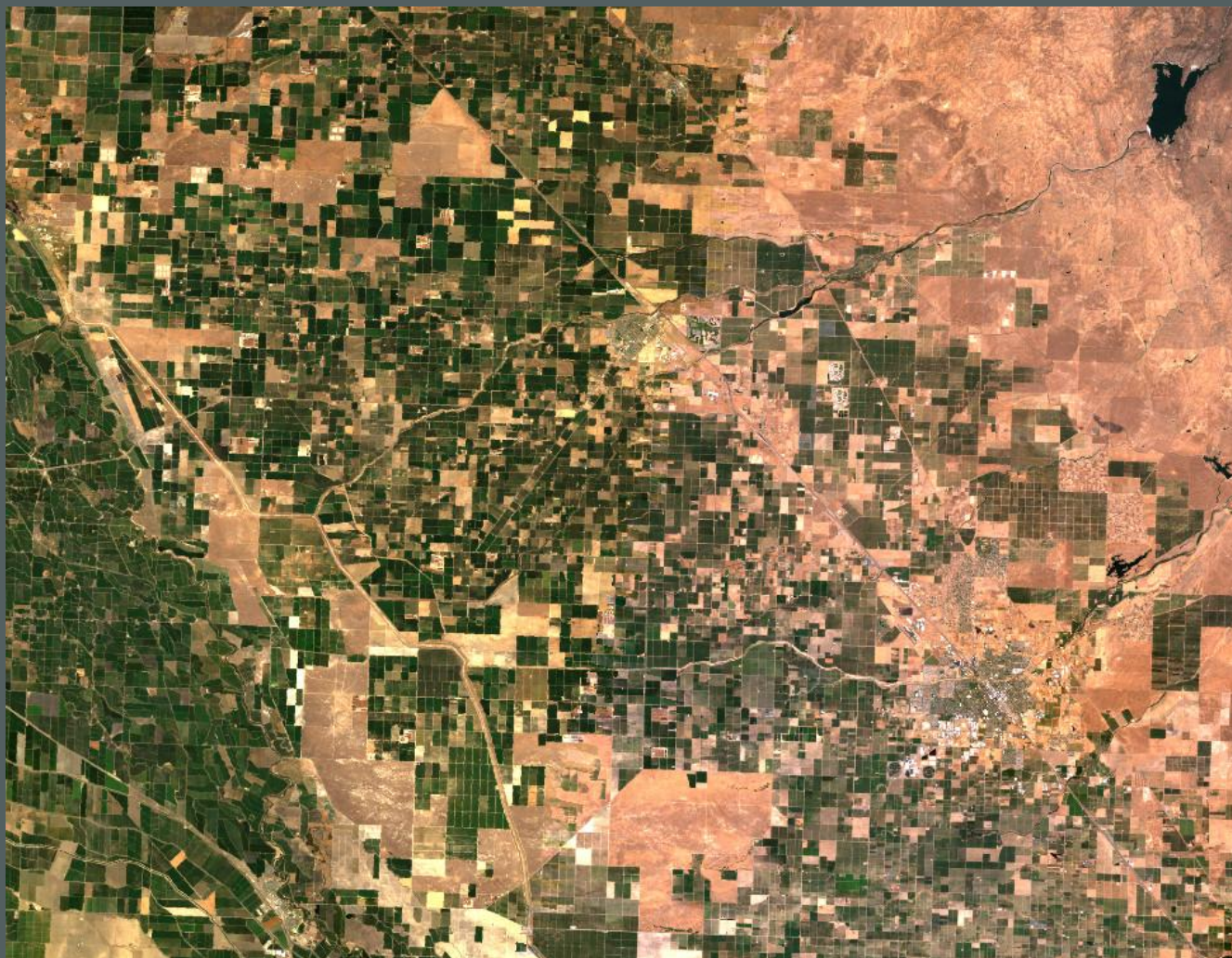
43/34
JUL 22 07



42/34
JUL 28 06

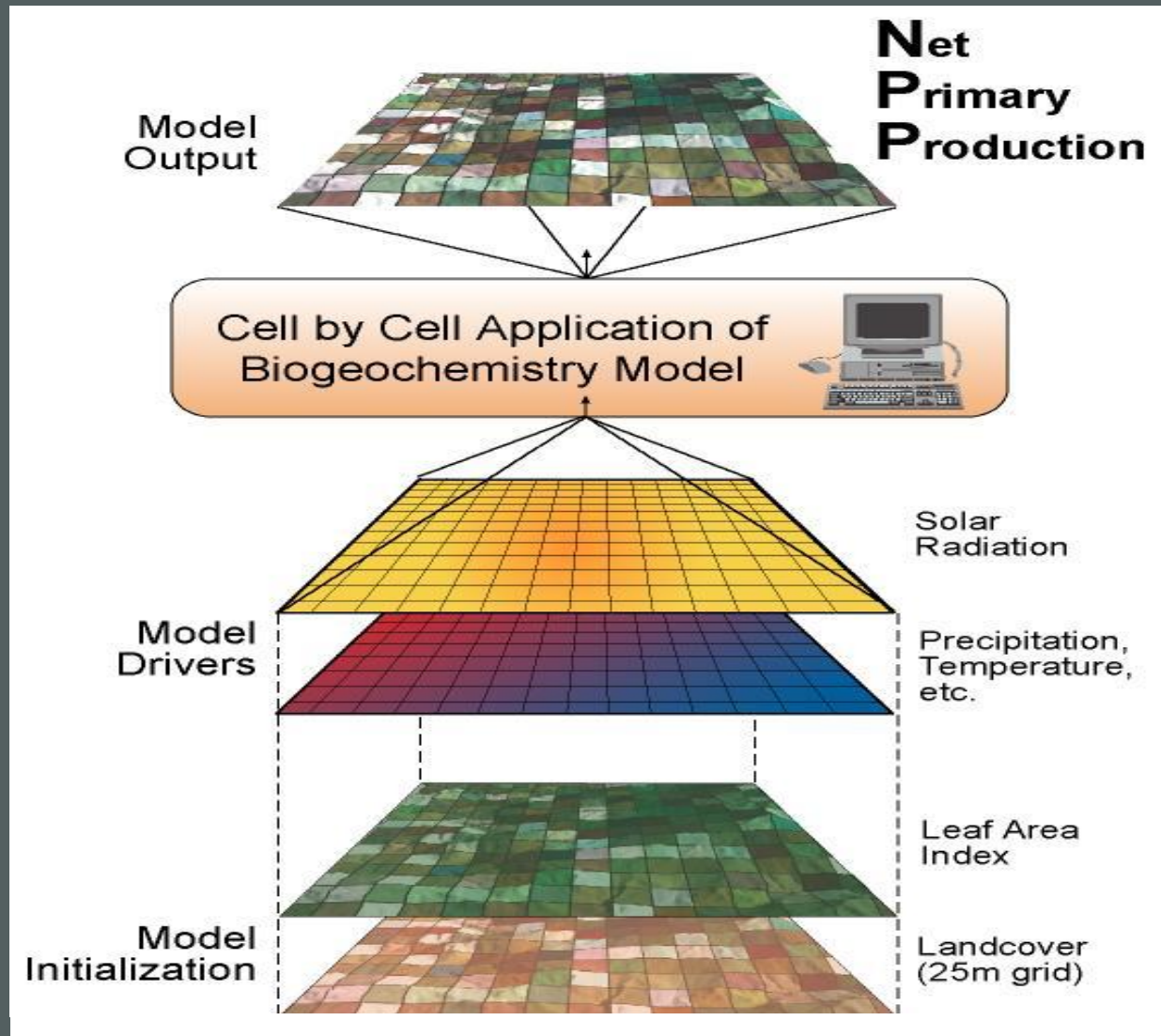
Surface Reflectance

43/34
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JUL 28 06

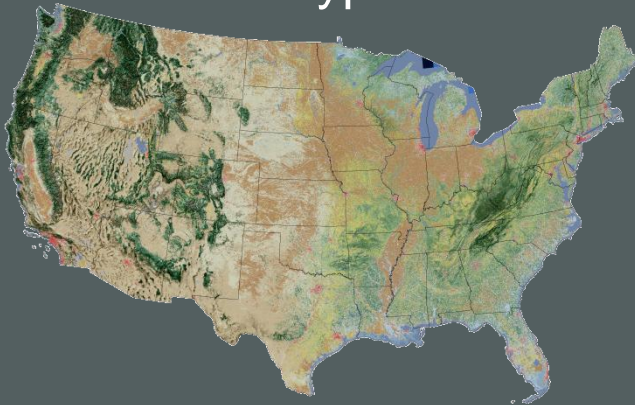
Value of ECVs as Inputs to Models



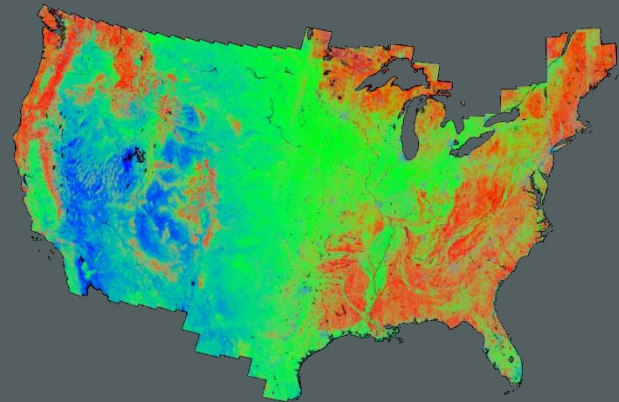
Transitioning to Operational Land Cover ECV's

Current capabilities – NLCD every 5 years

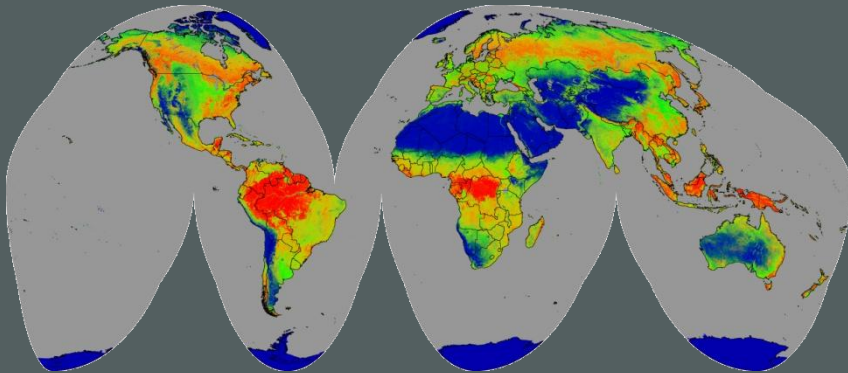
Land cover types



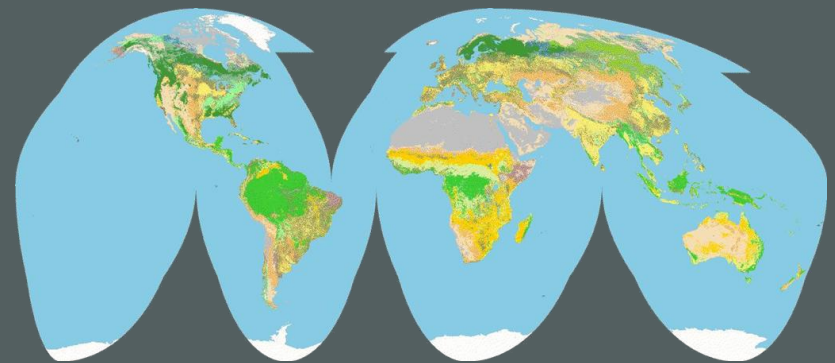
Land cover continuous variables



Future land cover ECVs – annual and 5 year global datasets



Annual land cover continuous variables

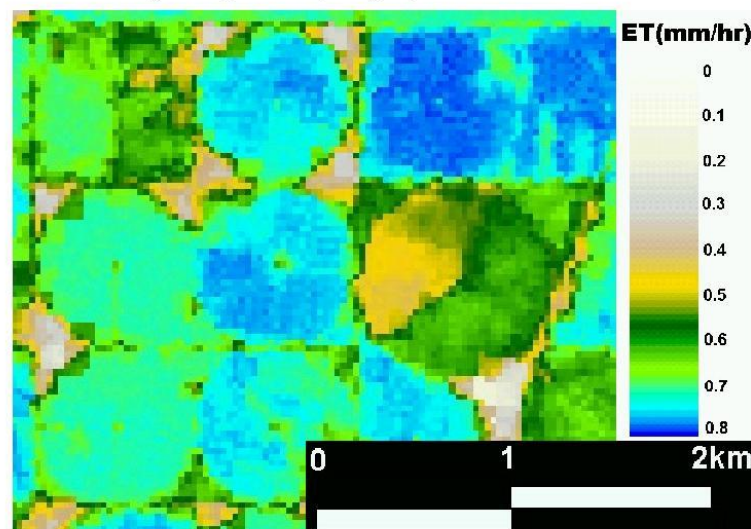


Mid-decadal land cover types

ET Estimation with Landsat TIR Data

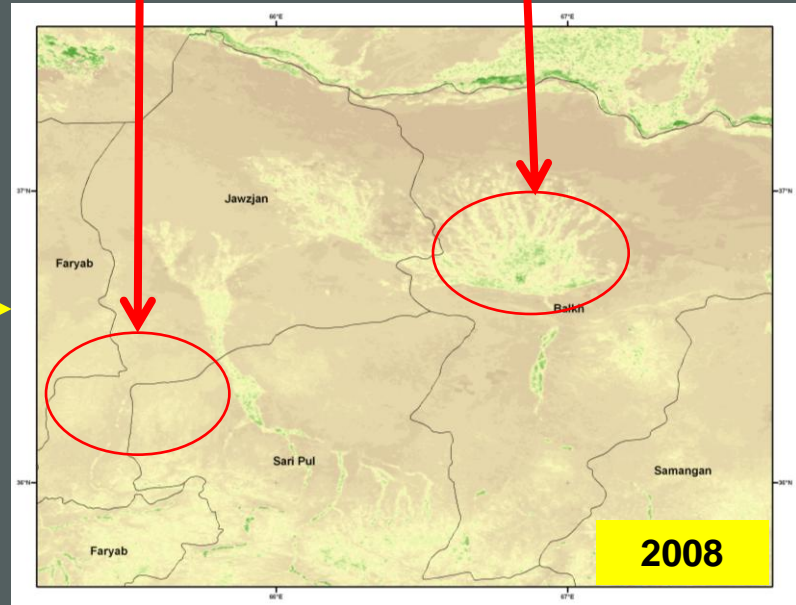
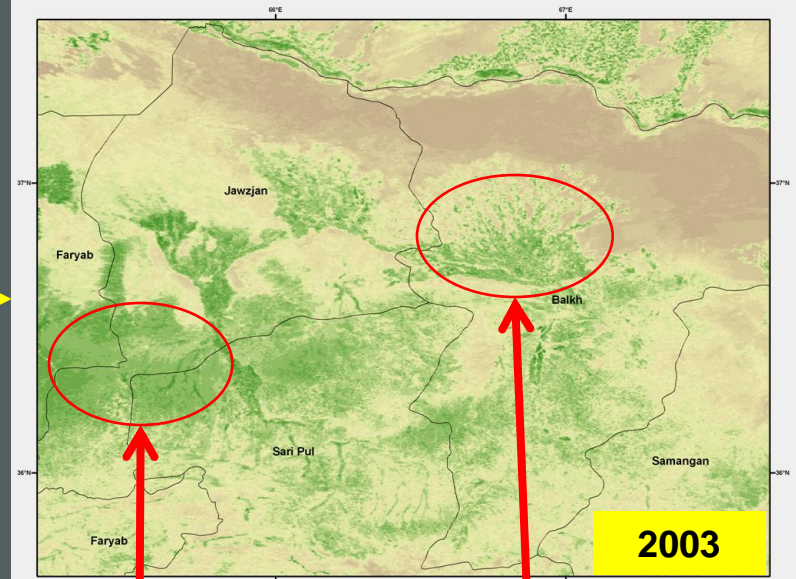
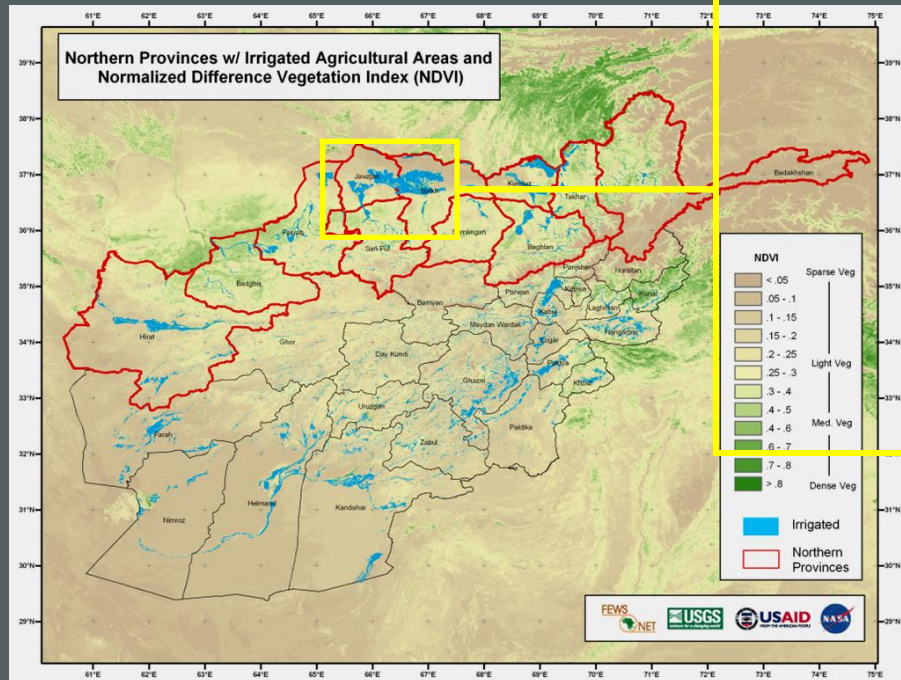
- Used to monitor crop water use on a field-by-field basis
- Used routinely in 13 states and 26 countries
- WaterSMART and USGS water use reporting
- Drought detection

Evapotranspiration at time of Landsat overpass
Oakley Fan, Idaho, July 7, 1989



Afghanistan Drought Impact on 2008 Harvest

Maximum NDVI 2003 vs. 2008 for rain fed and irrigated crops

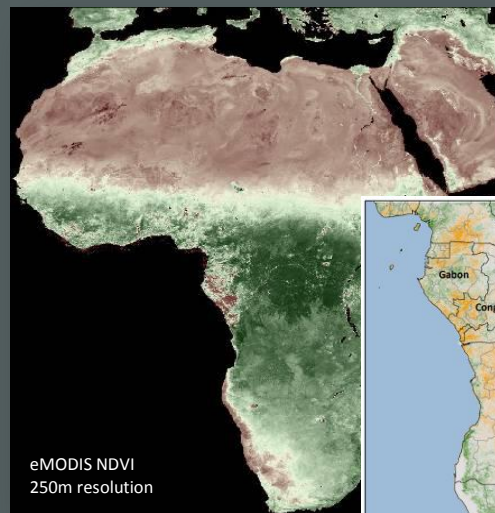
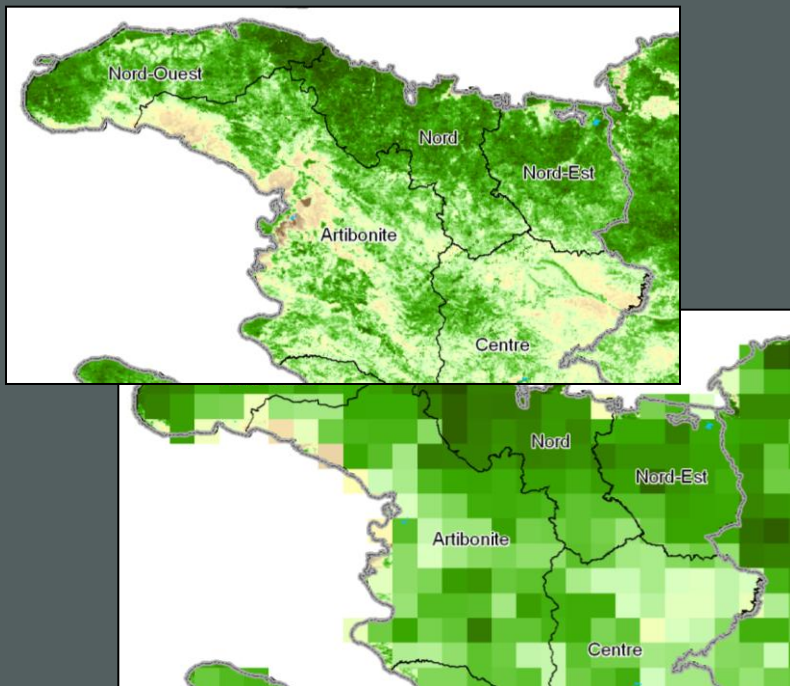


Severity of Drought Anomalies Revealed

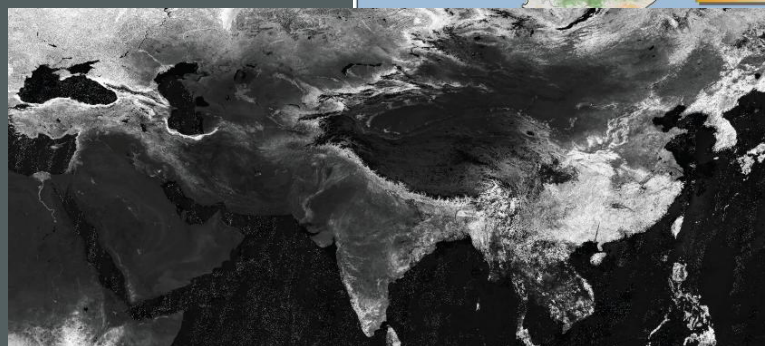
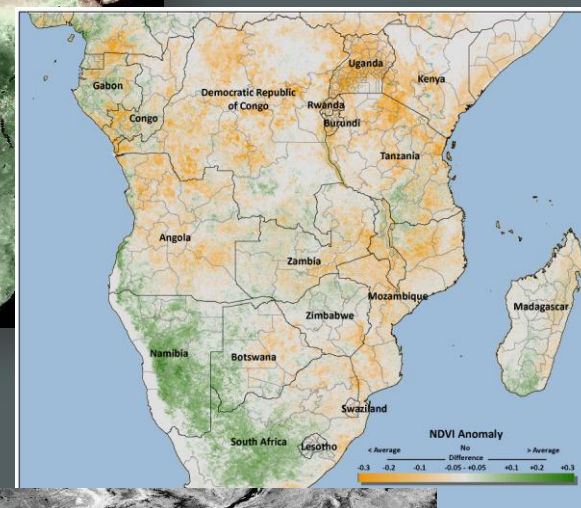
Annual Maximum NDVI Ranking for Rainfed Northern Provinces											
Badakhshan		Badghis		Baghlan		Balkh		Faryab		Hirat	
Max NDVI	Year	Max NDVI	Year	Max NDVI	Year	Max NDVI	Year	Max NDVI	Year	Max NDVI	Year
0.34	2004	0.44	2003	0.45	2004	0.40	2003	0.41	2002	0.36	2003
0.32	2007	0.40	2002	0.39	2003	0.34	2002	0.40	2003	0.33	2002
0.32	2002	0.35	2007	0.38	2002	0.33	2005	0.33	2007	0.30	2005
0.30	2006	0.34	2005	0.36	2005	0.32	2004	0.33	2005	0.30	2007
0.30	2000	0.29	2006	0.35	2006	0.32	2007	0.29	2006	0.28	2006
0.29	2005	0.28	2004	0.31	2007	0.29	2006	0.29	2004	0.27	2004
0.29	2001	0.22	2008	0.26	2000	0.25	2000	0.23	2000	0.21	2001
0.27	2008	0.20	2000	0.23	2001	0.20	2001	0.20	2008	0.21	2000
0.27	2003	0.17	2001	0.21	2008	0.16	2008	0.17	2001	0.20	2008
Jawzjan		Kunduz		Samangan		Sari Pul		Takhar		Northern Provinces	
Max NDVI	Year	Max NDVI	Year	Max NDVI	Year	Max NDVI	Year	Max NDVI	Year	Max NDVI	Year
0.44	2003	0.48	2003	0.32	2004	0.40	2003	0.42	2004	0.39	2003
0.41	2002	0.47	2004	0.29	2003	0.37	2002	0.41	2003	0.37	2002
0.36	2007	0.39	2007	0.29	2002	0.34	2005	0.40	2002	0.34	2004
0.35	2005	0.39	2005	0.28	2005	0.34	2007	0.38	2005	0.34	2005
0.32	2006	0.38	2006	0.26	2007	0.32	2006	0.37	2006	0.33	2007
0.31	2004	0.37	2002	0.25	2006	0.30	2004	0.35	2007	0.31	2006
0.27	2000	0.31	2000	0.21	2000	0.26	2000	0.30	2000	0.26	2000
0.20	2001	0.27	2001	0.20	2001	0.22	2001	0.30	2001	0.22	2001
0.19	2008	0.24	2008	0.16	2008	0.17	2008	0.25	2008	0.21	2008

Vegetation Monitoring – eMODIS NDVI

- Normalized Difference Vegetation Index (NDVI)
- Used extensively to monitor crop and pasture conditions
- Real time updates produced by the NASA LANCE – USGS eMODIS processing chain



eMODIS 250m Anomaly
March 10 - 20, 2011



Summary

- **Climate variability, climate change, and land surface change pose enormous challenges to society in the decades ahead**
- **Adaptation strategies must be informed by historical assessments, projections, and ongoing monitoring**
- **Remote sensing is vital to the spatially and temporally complete observational record required to model climate-sensitive terrestrial processes – past, present, and future**

Summary

- USGS has a long history of land remote sensing for science and applications
- USGS has re-organized around science objectives, heightening the emphasis
- National Space Policy calls for USGS Operational Mission
- Operational production of CDRs and ECVs
- Provide evidence base for decision making
- *Calibration and validation are essential to achieving the Space Policy vision for DOI*

Thank you